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Results of the Summer 1991 R/V *Chapman* Marine Mammal Sighting Survey

by

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ABSTRACT

The first NMFS systematic survey of marine mammals in shelf-edge waters off the northeastern U.S. was conducted using the NOAA R/V Chapman from 8 June to 16 July 1991. The survey was designed to document fine scale distribution and habitat use of marine mammals in the shelf-break region, and to provide an estimate of cetacean abundance. The study area extended from Cape Hatteras, North Carolina to Georges Bank. Survey transects covered 3,494 km, of which 90% (3,128 km) was in shelf-edge waters between the 100 fm and 1000 fm isobaths (183-1,829 m).

Four hundred and sixty-three sightings of 15 identifiable species were made. Pilot whales (13.2%, n=61/463) and sperm whales (12.5%, n=58/463) were the most frequently sighted species. The majority of large whale sightings were solitary animals, while most delphinid groups, excluding pilot whales, contained six or more animals. Cetacean association with Gulf Stream features was documented via hydrographic samples and satellite sea surface temperature imagery.

Abundance estimates of the six most frequently sighted species (with coefficients of variation in parentheses) were: 9,106 (0.363) bottlenose dolphins; 22,215 (0.402) common dolphins; 11,017 (0.581) Risso's dolphins; 3,636 (0.360) pilot whales; 262 (0.998) beaked whales; and 736 (0.325) sperm whales.

INTRODUCTION

The shelf break off the U.S. northeast coast is characterized by numerous submarine canyons (Emery and Uchupi 1972), and shelf - slope water characteristics are frequently influenced by Gulf Stream features (Olson and Backus 1985; Cornillon 1985). Cetacean distribution along bathymetric features is generally associated with spatial and temporal patterns in prey abundance (Gaskin 1985; Hui 1985; Whitehead and Glass 1985; Kenney and Winn 1987; Selzer and Payne 1988). Along the continental shelf margin of the northeast U.S., bathymetric features form extensive linear high use cetacean habitats (CeTAP 1982; Hain et al. 1985; Payne and Heinemann 1993).

Systematic seasonal surveys (principally aerial) conducted during 1979-1981 across the northeast U.S. continental shelf indicate that cetacean distribution patterns and density in shelf edge waters are highly variable (CeTAP 1982; Kenney and Winn 1987). Similar findings were obtained during 1980-1987, when cetacean sightings data were collected in conjunction with Northeast Fisheries Science Center research vessel surveys (Smith et al. 1996).

This paper presents information on the distribution, sighting frequency, group size, and abundance of cetaceans in shelf-edge waters between Cape Hatteras and Georges Bank, based on the data collected from the first shipboard marine mammal survey conducted in this region (Anon 1991; Waring et al. 1992). The purpose of this document is to provide a reference for several of the cetacean abundance estimates provided in the first and second edition of the report "U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments" (Blaylock et al. 1995; Waring et al. 1997). [1]

METHODS

Survey Sampling

During June 8 to July 16, 1991, the National Oceanic and Atmospheric Administration (NOAA) 34m fisheries research vessel R/V CHAPMAN was used to conduct a marine mammal sighting survey in shelf edge and oceanic waters off the northeastern U.S. coast (Figure 1).

The objectives of this survey were to: 1) investigate fine scale distribution and habitat utilization of cetaceans within canyons, along the shelf/slope edge, and within warm core rings in the shelf-break region 2) determine if the distribution of marine mammals was continuous between several major canyons areas and 3) conduct line-transect population abundance surveys along the shelf break.

[1]Parts of this manuscript were excerpted from Waring et al. (1992).

The survey was conducted in three legs: from Cape Hatteras to the Hudson Canyon region; from Oceanographer Canyon to waters south of Cape Cod; and from Lydonia Canyon to the Northeast Channel (Figure 1). A predetermined zig-zag cruise track was followed, although some areas were not surveyed due to military closures, weather problems, and assisting in the release of satellite tagged pilot whales. These factors resulted in several gaps in survey effort, particularly off the Delmarva region and between eastern Long Island and Cape Cod (Figure 1).

Vessel speed under normal searching conditions was 9.5-10.5 kt. Marine mammal sightings were collected daily between 0700 and 1900 hrs, conditions permitting, using standard line transect procedures (Buckland et al. 1993).

The sighting team consisted of three observers (port, center, and starboard) who searched from the catwalk of the pilot house. Individuals were randomly assigned to each position at the start of each day. Observers maintained 45 minute watches with a 15 minute rest period and a 15 minute data recording period. Positions were rotated every 15 minutes. Primary searching was done with the naked eye, but 7x50 binoculars were used to confirm initial sightings, and to determine species identification, group size, and swimming direction. Visual estimates were made of the radial distance to each sighting. Sighting angle was determined using a pelorus mounted at each observer station.

Observers were instructed to identify species to the lowest level possible, based on key field characteristics, body size / shape and color. If species identification could not be determined, observers were instructed to assign the sighting to the "best" next highest taxonomic group. The group names ranged from very general (i.e., large whale, dolphin) to specific (i.e., *Stenella* spp., *Mesoplodon* spp.).

Sea surface bucket temperatures were taken every 15 minutes. A Seabird Electronics CTD Profiler or expendable bathythermographs (XBT's), deployed to 200m, were used to obtain water column hydrographic data.

Sea surface temperature (SST) images were also collected using the advanced very high resolution radiometer (AVHRR) aboard the NOAA-11 satellite. These data, preprocessed at the University of Miami and routinely transmitted to the University of Rhode Island for further processing, were analyzed by the NOAA Remote Sensing Group, NEFSC, Narragansett, RI using methods described in Cornillon et al. (1987). Images were remapped to display the study area in a 512 x 512 pixel image. These images have a temperature resolution of 0.125^0 C (Schwalb 1978), temperature accuracy of 0.75^0 C (Cornillon and Stramma 1985) and spatial resolution of 1 km at nadir.

Processed satellite images, sightings, and transect data were incorporated into a ARC/INFO[2] geographic information system for display and data analysis.

Analytical Methods

Abundance estimates were estimated using distance sampling analysis for line transect surveys (Buckland et al. 1993). The survey area was post stratified based on geographical and environmental parameters, and species distribution patterns. The strata were defined as: Georges Bank northern edge, Georges Bank shelf-edge, mid-Atlantic shelf-edge, and slope water (Figure 1; Table 1). The strata delineated by the dashed lines in figure 1 are for display purposes only, actual strata boundaries are difficult to discern because they closely bound the 100 and 1,000 fm curves and transect endpoints. Abundance estimates were made using the computer package DISTANCE (Laake et al. 1993). The formula used to estimate density ($\hat{D}$) was

$$\hat{D} = \frac{\sum_{strata\ i}^{n} \frac{n_i \cdot \hat{S}_i \cdot \hat{f}(0)}{2 \cdot L_i} \cdot A_i}{\sum_{i}^{n} A_i}$$

where

	n_i	=number of on-effort sightings for stratum i
	$\hat{S}_I$	=best estimate of average group size for stratum i, bias corrected if needed
	$\hat{f}(0)$	=sighting probability density function, evaluated at zero perpendicular distance, using data from all strata
	L_i	=length of transects sampled within a stratum i.
	A_i	=area of stratum i (stratum weight)

Abundance was derived at estimated density times the size of the total survey area (56,272 km^2), and log-normal 95% confidence intervals were computed for each abundance estimate. For each species, the parameter $\hat{f}(0)$ was estimated by fitting the distribution of all perpendicular sighting distances over all strata (Laake et al. 1993). Several iterations of each "species model" were conducted to examine the utility of several model options (i.e., data truncation). Model selection of $\hat{f}(0)$ was determined using Akaike's Information Criterion (AIC; Buckland et al. 1993). Goodness-of-fit was examined using the Chi-squared test, and visual inspection of the fit near the origin (Laake et al. 1993). School size-bias was investigated using the computer package

[2]The National Marine Fisheries Service does not approve, recommend, or endorse any proprietary product mentioned in this report.

DISTANCE (Laake et al. 1993) by regressing ln (group size) onto the probability of group detection, g(x). If the slope of the regression was significant (i.e., size-bias exists), then the corrected average school size was used in the above equations.

None of the abundance estimates were dive-time corrected or adjusted for g(0), the probability of detecting animals on the trackline. Variances of the abundance estimates were estimated using bootstrap resampling techniques.

RESULTS

Survey transect[3] covered 3,494 km, of which 90% (3,128 km) was in shelf-edge waters between the 100-fm and 1000-fm isobaths (183-1,829 m). A total of 266 km (7.6%) of effort was conducted in off-shelf waters while 100 km (2.9%) was conducted along the northern edge of Georges Bank (Figure 1). Most of the survey transects (2,900 km; 83%) were accomplished in Beaufort 3 or less.

A total of 463 marine mammals were sighted and 88% of these sightings were in Beaufort 3 or less (Table 2). Unidentified dolphins (25.7%, n= 119) and unidentified whales (12.3%, n=57) accounted for over a third of the total sightings (Table 3). The most frequently sighted identifiable cetaceans were pilot whales (*Globicephala* spp.) (13.2%, n=61/463) and sperm whales (12.5%, n=58/463) (Table 3). The majority of large whale sightings were solitary animals. Most of the delphinid groups, excluding pilot whales, contained six or more animals.

Hydrographic data were collected at 100 stations, 48 CTD's and 52 XBT's (Figure 2). Sea surface temperatures $\geq 21^0$ C are indicative of Gulf Stream features (i.e., stream and rings) (Figure 1).

Species Distribution

Common dolphins (Figure 3) were observed along the north wall of the Gulf Stream where it abuts the shelf-break (approximately 35^0N 30'W). Sightings were also made in Oceanographer, Hydrographer, and Block Canyons, and near Hudson Canyon where no thermal front was detectable. Common dolphins were seen on Georges Bank shoreward of Oceanographer Canyon along a noticeable thermal front, and along the edge of a warm-core ring which was in close proximity to the southeastern bathymetric edge of Georges Bank.

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[3] Effort data reported here corresponds to data used in the Program DISTANCE, but is less than total effort (4,032 km) reported in Waring et al. 1992. The former included effort in some near shore areas.

The majority of Risso's dolphins sightings occurred along the shelf break, scattered from Baltimore to Lydonia Canyons, in the area of a warm-core ring remnant near Hydrographer Canyon, and in the shelf waters shoreward of the 100-fm isobath (Figure 3). This species was often found near canyons where no associated thermal front was noticeable.

Most pilot whale sightings (Figure 3) occurred along the shelf break, including in canyons (principally Oceanographer, Hydrographer, and Corsair Canyons) along the southern edge of Georges Bank, both in areas where a thermal front coincided with the bathymetric front, as well as where this co-occurrence was lacking. Some sightings were also made along the north wall of the Gulf Stream, which coincided with the bathymetric break near Cape Hatteras, and along a warm-core ring and ring remnants, which were also near bathymetric fronts.

Numerous bottlenose dolphin sightings were made along the bathymetric shelf break in areas both with, and without, accompanying thermal fronts (Figure 4). Bottlenose dolphins were also seen in the Gulf Stream, along the north wall of the Gulf Stream, in the canyons along the southern edge of Georges Bank.

Three *Stenella* species were observed during the surveys, including spotted dolphins (*Stenella* spp.), striped dolphins (*S. coeruleoalba*), and spinner dolphins (*S. longirostris*). Due to the small number of sightings for each species, the distribution (Figure 4) of all three species is jointly described. *Stenella* were sighted along the north wall of the Gulf Stream (which coincided with the shelf break bathymetric front), along the shelf break (which also coincided with a thermal front), along the edges of a warm-core ring remnant near the shelf break and a warm-core ring near the southern edge of Georges Bank, and in the slope waters near a relatively weak thermal front.

Although beaked whales (Family Ziphiidae) are difficult to identify to species in the field, three different species were sighted in the 1991 survey: goosebeaked whales (*Ziphius cavirostris*), True's beaked whales (*Mesoplodon mirus*), and North Sea beaked whales (*M. bidens*). Observations were also made of unidentified beaked whales. Due to the low number of total beaked whale sightings (7), analyses were performed on the family in general, rather than individual species. Beaked whale sightings (Figure 5) occurred near Oceanographer Canyon between 100-fm and 1000-fm isobaths (which did not coincide with a noticeable thermal gradient) and along the 1000-fm isobath, which coincided with the edge of a large warm-core ring near southeastern Georges Bank (Waring et al. 1992). One sighting was made in slope water southeast of Hudson Canyon. No beaked whales were recorded along the mid-Atlantic shelf edge.

Sperm whales were generally distributed between the 100-fm and 1000-fm isobaths, including an area where the remnant of a warm-core ring was located (Figure 5). Sightings were also made along the north wall of the Gulf Stream where it abuts the shelf-break (approximately 35°N 30'W). Few sperm whales were observed in the slope waters between the shelf break and the Gulf Stream.

Scattered sighting of fin whales were made along the 100-fm isobath in waters south of Georges Bank (Figure 5). Sightings on Georges Bank occurred along the southern and northern edges, but most were aggregated east of the U.S./Canadian maritime boundary in the vicinity of Georges and Corsair Canyons.

These distribution patterns suggest that Gulf Stream features are important habitats for several shelf-edge and slope water species, although the exact use of these features could not be discerned.

Abundance

Abundance estimates (Table 4) were derived for six species (bottlenose dolphin, common dolphin, Risso's dolphin, pilot whales, beaked whales, and sperm whales). Sightings data for spinner dolphin, spotted dolphin, striped dolphin, white-sided dolphin, sei whale, minke whale, and pygmy sperm whale were judged to be insufficient for analysis using the program DISTANCE. Estimates for humpback whales and fin whales were not made because humpback whale abundance is assessed from mark-recapture analysis of photoidentification data, and only a small component of fin whale summer habitat was covered in the survey.

Abundance estimates for bottlenose dolphins, Risso's dolphins, and sperm whales were highest along the mid-Atlantic shelf break (Table 4); whereas, estimates for common dolphins, pilot whales and beaked whales were highest along the Georges Bank shelf edge.

The CVs for the abundance estimates ranged from 0.325 (sperm whales) to 0.998 (beaked whales), and all exceeded the survey target level of 0.30 (Table 3).

DISCUSSION

Distribution of cetaceans seen along the shelf-edge in this survey were generally similar to those reported by CETAP (1982). Latitudinal gradation in species composition in both the 1991 and CETAP surveys is likely related to prey distribution patterns, foraging strategies, or thermal preferences. The shelf-break is a high use cetacean habitat, because of elevated productivity resulting from complex oceanographic processes (Kenney and Winn 1987). Gulf Stream ring features probably enhance shelf-edge productivity, by attracting large predators (Olson and Backus 1985; Mann and Lazier 1991). Seasonally, these habitats are utilized by migratory species of fish and squid that support important, economically valuable fisheries (Podesta et al. 1993; Smith et al. 1996).

Ten cetaceans (fin, sperm, beaked, pilot whales, Risso's, bottlenose, common, and *Stenella* dolphins) were distributed along the Gulf Stream north wall suggesting that this is an important habitat. All of these species except fin whales were also seen associated with warm-core rings.

The low number of sightings in slope water may represent a discontinuity in habitat use between shelf-edge and Gulf Stream features, or an artifact of the low level of sighting effort in these waters. A broader scale survey conducted during summer 1995 (NMFS unpublished data) suggests that slope waters, not influenced by Gulf Stream features, are low density cetacean habitats.

Only beaked and sperm whales, and bottlenose and *Stenella* dolphins were sighted within the Gulf Stream, which is consistent with the oceanic distribution of these species and the *Stenella* preference for warm waters (Leatherwood et al., 1976; Jefferson et al. 1993).

Comparisons were made with CETAP (1982) summer abundance estimates, but they may not be directly comparable because CETAP estimates were based on multi-year aerial surveys, and include on shelf effort

1991 and CETAP Summer Abundance Estimates

Species	1991	CETAP
Bottlenose dolphins	9,106	8,213
Risso's dolphins	11,017	11,678
Common dolphins	22,215	8,213
Pilot whales	3,636	9,808
Beaked whales	262	121
Sperm whales	736	216

The 1991 and CETAP abundance estimates were similar for bottlenose dolphins and Risso's dolphins. The abundance estimated for common dolphins was nearly eight-fold higher than the CETAP estimate, but was close to the CETAP spring (17,259) and autumn estimates (24,828). This suggests that survey timing is an important criteria in cross-surveys comparisons. Pilot whale abundance from the 1991 survey was nearly 60% below the CETAP estimate. Summer surveys may not provide the best estimate of pilot whale abundance off the northeast U.S. coast, because an unknown, perhaps significant, component of the population migrates into Canadian waters (Sergeant 1962; Payne and Heinemann 1993). Abundance estimates for beaked whales and sperm whales in 1991 were at least twice as large as the CETAP estimates. The higher estimates obtained for beaked and sperm whales in the 1991 survey is consistent with the level of effort in high use shelf-edge and oceanic water habitats.

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Table 1. Strata, strata area, and transect distances within each strata during R/V Chapman 91-03 marine mammal survey, 8 June to 16 July 1991

Strata	Area (km^2)	Length (km) of Survey Transects
Mid-Atlantic Shelf-Edge	26,600 (50.3%)	1794 (51.3%)
Georges Bank Shelf-Edge	18,400 (34.8%)	1334 (38.2%)
Slope Water	4,770 (9.0%)	266 (7.6%)
Georges Bank Northern Edge	3,100 (5.9%)	100 (2.9%)
Total	52,870 (100.0%)	3,494 (100.0%)

Table 2. Number of sightings by Beaufort scale during R/V Chapman 91-03 marine mammal survey, 8 June to 16 July 1991

Species	Beaufort						
	0	1	2	3	4	5+	Total
Humpback whale	0	3	1	2	6	0	12
Fin whale	0	10	3	10	3	2	28
Sei whale	0	0	0	2	0	0	2
Minke whale	0	0	0	1	0	0	1
Sperm whale	1	6	21	21	8	1	58
Pygmy sperm whale	0	0	1	0	0	0	1
Beaked whale	0	3	2	2	0	0	7
Pilot whale	0	16	23	19	3	0	61
Risso's dolphin	0	2	9	3	3	0	17
Bottlenose dolphin	0	11	10	14	4	1	40
Common dolphin	1	6	18	16	0	2	43
Spinner dolphin	0	1	1	0	0	0	2
Spotted dolphin	0	0	3	0	0	3	6
Striped dolphin	0	1	2	3	1	0	7
White-sided dolphin	0	0	2	0	0	0	2
Unid. whale	2	11	20	13	9	2	57
Unid. dolphin	1	19	45	45	7	2	119
Total	5	89	161	151	44	13	463

Table 3. Frequency of sightings by group size during R/V Chapman 91-03 marine mammal survey, 8 June to 16 July 1991

Species	Group Size 1	2-5	6-10	11-20	>20	Total Sightings	Total # Animals	% Total Sightings
Humpback whale	8	2	2	0	0	12	24	2.59
Fin whale	21	6	1	0	0	28	45	6.05
Sei whale	1	1	0	0	0	2	3	0.43
Minke whale	1	0	0	0	0	1	1	0.22
Sperm whale	30	25	1	2	0	58	129	12.53
Pygmy sperm whale	1	0	0	0	0	1	1	0.22
Beaked whale	1	4	2	0	0	7	29	1.51
Pilot whale	4	23	15	11	8	61	724	13.17
Risso's dolphin	0	4	8	2	3	17	333	3.67
Bottlenose dolphin	4	8	9	12	7	40	588	8.64
Common dolphin	1	3	4	8	27	43	3493	9.29
Spinner dolphin	1	0	0	1	0	2	21	0.43
Spotted dolphin	0	1	0	2	3	6	392	1.30
Striped dolphin	0	1	0	0	6	7	916	1.51
White-sided dolphin	0	0	0	0	2	2	925	0.43
Unid. Whale	49	7	0	0	1	57	73	12.31
Unid. Dolphin	20	20	22	17	40	119	4344	25.70

Table 4. Estimated abundance (N) and density estimates (per km^2) by species for the R/V Chapman 91-03 marine mammal survey, 8 June - 16 July 1991, principally in shelf-edge waters from Cape Hatteras to Georges Bank, and associated % coefficient of variation (CV) and log-normal 95% confidence intervals (CI). (Upper confidence limit denoted by "ucl"; lower limit by "lcl.")

Species and area	On effort sightings[1]	Density	Estimated abundance(N)	CV(N)	Model	95% lcl	95% ucl
Bottlenose dolphins	34	0.1772	9,106	0.363	Uniform	4,572	18,138
Mid-Atlantic shelf-edge		0.2252	5,990				
Georges Bank shelf-edge		0.1514	2,786				
Slope water		0.0690	329				
Georges Bank northern edge		0	0				
Common dolphins	40	0.4202	22,215 (4,984)[2]	0.402	Uniform	10,412	47,398
Mid-Atlantic shelf-edge		0.1892	5,033				
Georges Bank shelf-edge		0.8914	16,402				
Slope water		0.1635	780				
Georges Bank northern edge		0	0				
Risso's dolphins	16	0.2084	11,017 (5,353)[2]	0.581	Uniform	3,677	33,009
Mid-Atlantic shelf-edge		0.2552	6,787				
Georges Bank shelf-edge		0.1407	2,588				
Slope water		0.3441	1,642				
Georges Bank northern edge		0	0				
Pilot whales	52	0.0678	3,636 (896)[2]	0.360	Uniform	1,836	7,202
Mid-Atlantic shelf-edge		0.0337	896				
Georges Bank shelf-edge		0.1255	2308				
Slope water		0	0				
Georges Bank northern edge		0.1393	432				
Beaked whales	5	0.0049	262	0.998	Half-normal	43	1,582
Mid-Atlantic shelf-edge		0	0				
Georges Bank shelf-edge		0.0107	198				
Slope water		0.0135	64				
Georges Bank northern edge		0					
Sperm whales	52	0.0139	736	0.325	Uniform	390	1,390
Mid-Atlantic shelf-edge		0.0178	446				
Georges Bank shelf-edge		0.0063	117				
Slope water		0.0362	173				
Georges Bank northern edge		0	0				

[1] Only on effort sightings were used in the anlaysis, thus these numbers are lower than the total sightings presented in Tables 2 and 3.

[2] These are the abundance estimates that were provided in the 1995 Atlantic and Gulf of Mexico Stock Assessment Report (NOAA Tech.

Memo. NMFS-SEFSC-363). The reported values are incorrect due to a coding error in the input files for DISTANCE, which was not detected until Spring 1997. At that time, a check was made on some of the DISTANCE analysis options used in processing the 1991 shipboard data, and the program rerun on a different computer. Some of the species abundance estimates obtained from the "Spring 97 runs" differed from those reported in the 1995 Assessments. The input files on the "1995 and 1997" computers were compared and deemed to be identical. Further comparisons suggested that a "hidden character" was contained in some of input files on the "1995" computer. The "hidden character" error caused the stratum weights for two strata to be treated as zero, thus the abundance estimates were artificially negatively biased. The NEW estimates reflect the correct stratum weights for all survey strata.

Except for common dolphin, the revised 1991 shipboard estimates do not affect any of the Potential Biological Removal (PBR) (MMPA Sec. 3. Definitions (16 U.S.C. 1362) levels contained in the 1995 and 1996 assessments. Until the aforementioned error was discovered, results of the NEFSC 1995 summer surveys were used in the 1996 assessments to update PBR's (including common dolphins) for the offshore pelagic complex. The 1995 survey design was superior to the 1991 survey, because it was devised to include the known summer habitat for several strategic stocks (based on historical survey and bycatch data), and to provide more precise abundance estimates, two independent sighting teams were used to estimate g(o).

However, due to weather restraints (4 hurricanes impacted the 1995 survey effort), nearly 50% of the proposed survey area along the southern flank of Georges Bank was not sampled. The unsampled region is important common dolphin summer habitat, thus affecting the 1995 abundance estimate for common dolphins. The "revised" 1991 common dolphin abundance estimate was deemed to be more appropriate for calculating PBR, NOT because the 1991 estimate (22,215) is greater than the 1995 estimate (6,741), but the earlier survey covered more of the species known habitat, particularly Georges Bank.

Revised estimates of the Minimum Population Estimate (Nmin) (MMPA Sec. 3. Definitions (16 U.S.C. 1362) and PBR for common dolphin using the "new" 1991 abundance estimates are: Nmin= 15,470 (CV=0.45), PBR= 155.

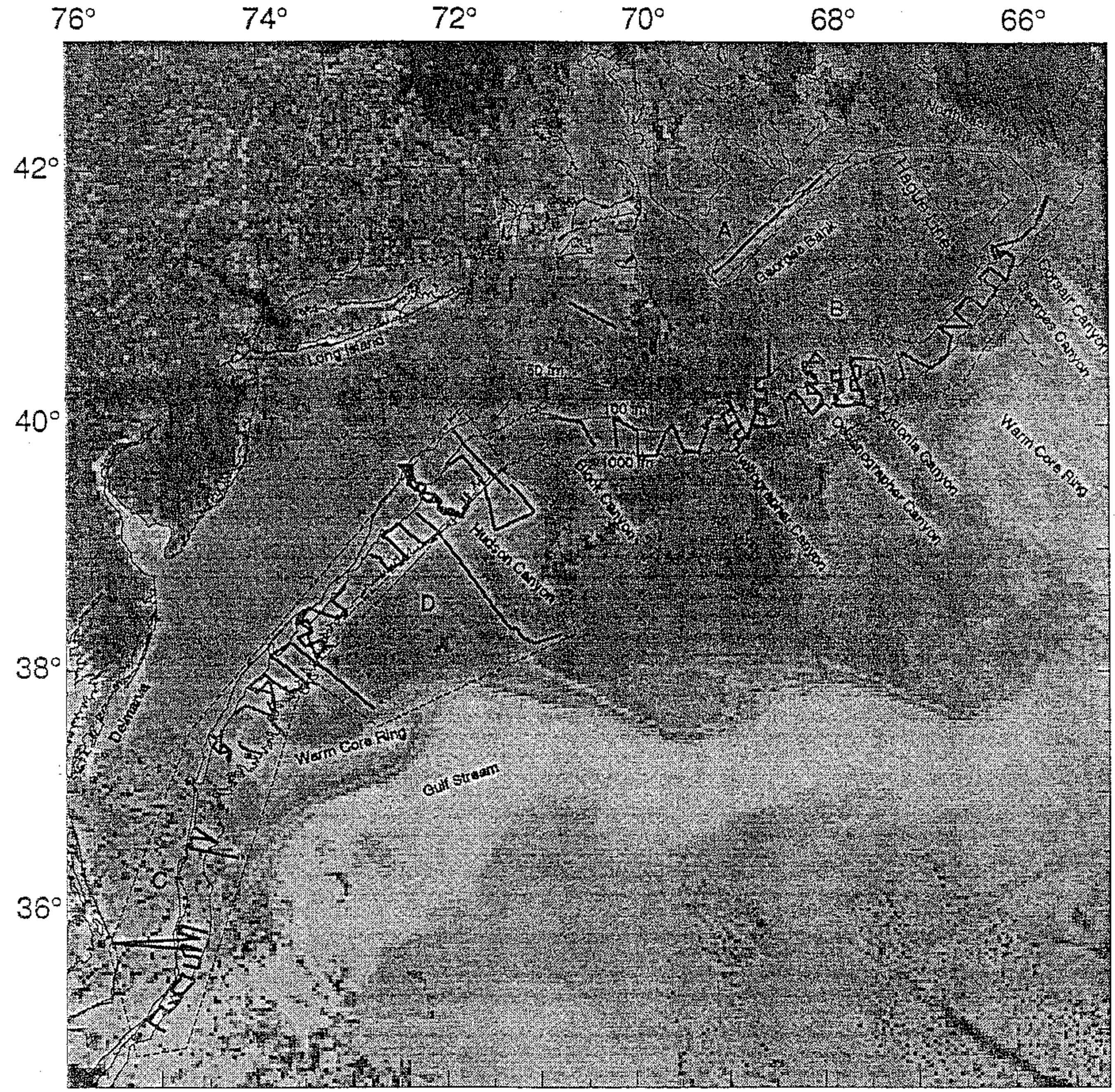

Figure 1. Geographic region and transect lines for R/V Chapman 91-03 marine mammal survey, 8 June - 16 July 1991. Polygons A-D, respectively, bracket the Georges Bank northern edge, Georges Bank shelf-edge, mid-Atlantic shelf-edge, and slope water strata.

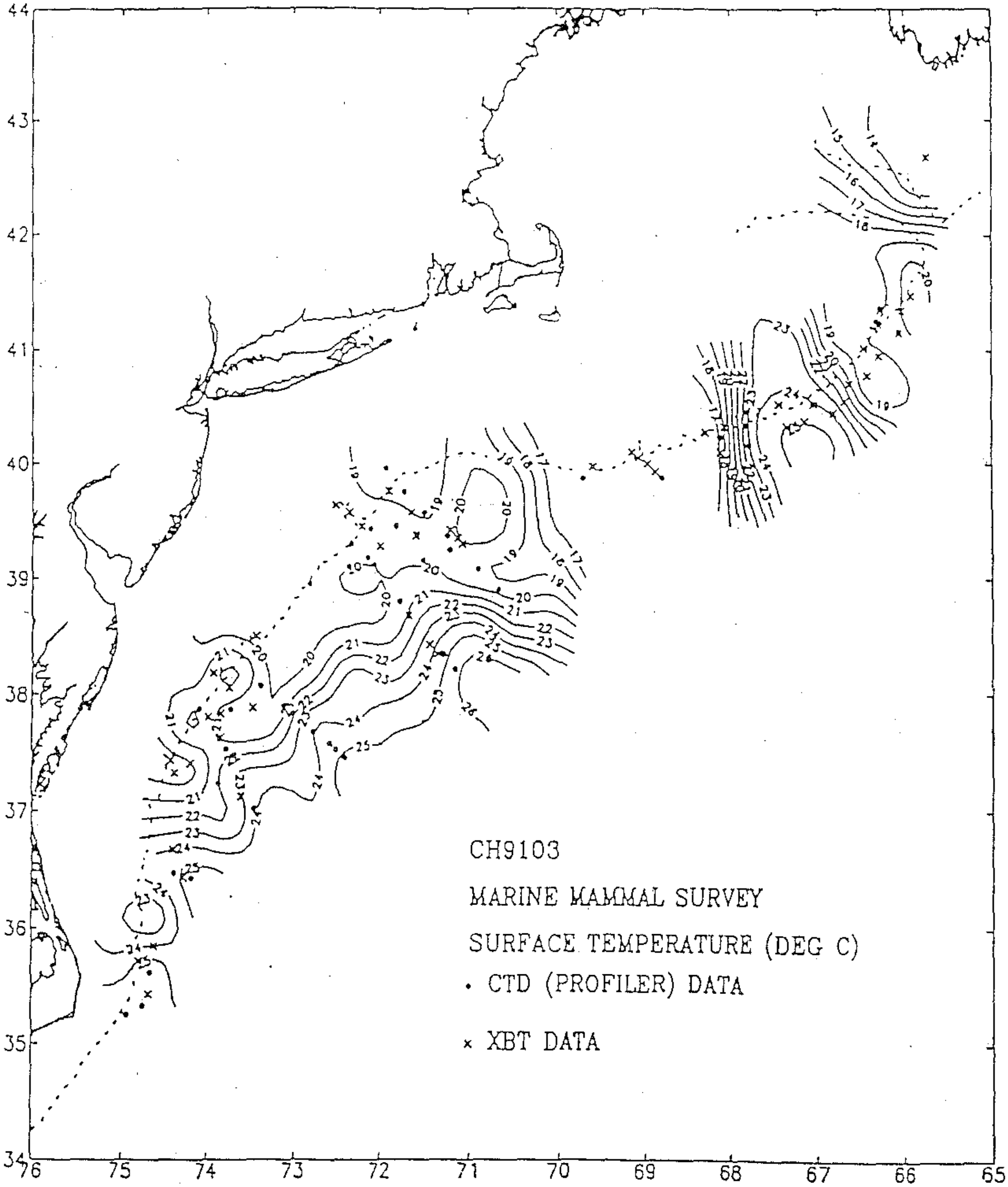

Figure 2. Sea surface temperature structure during R/V Chapman 91-03 marine mammal survey, 8 June - 16 July 1991.

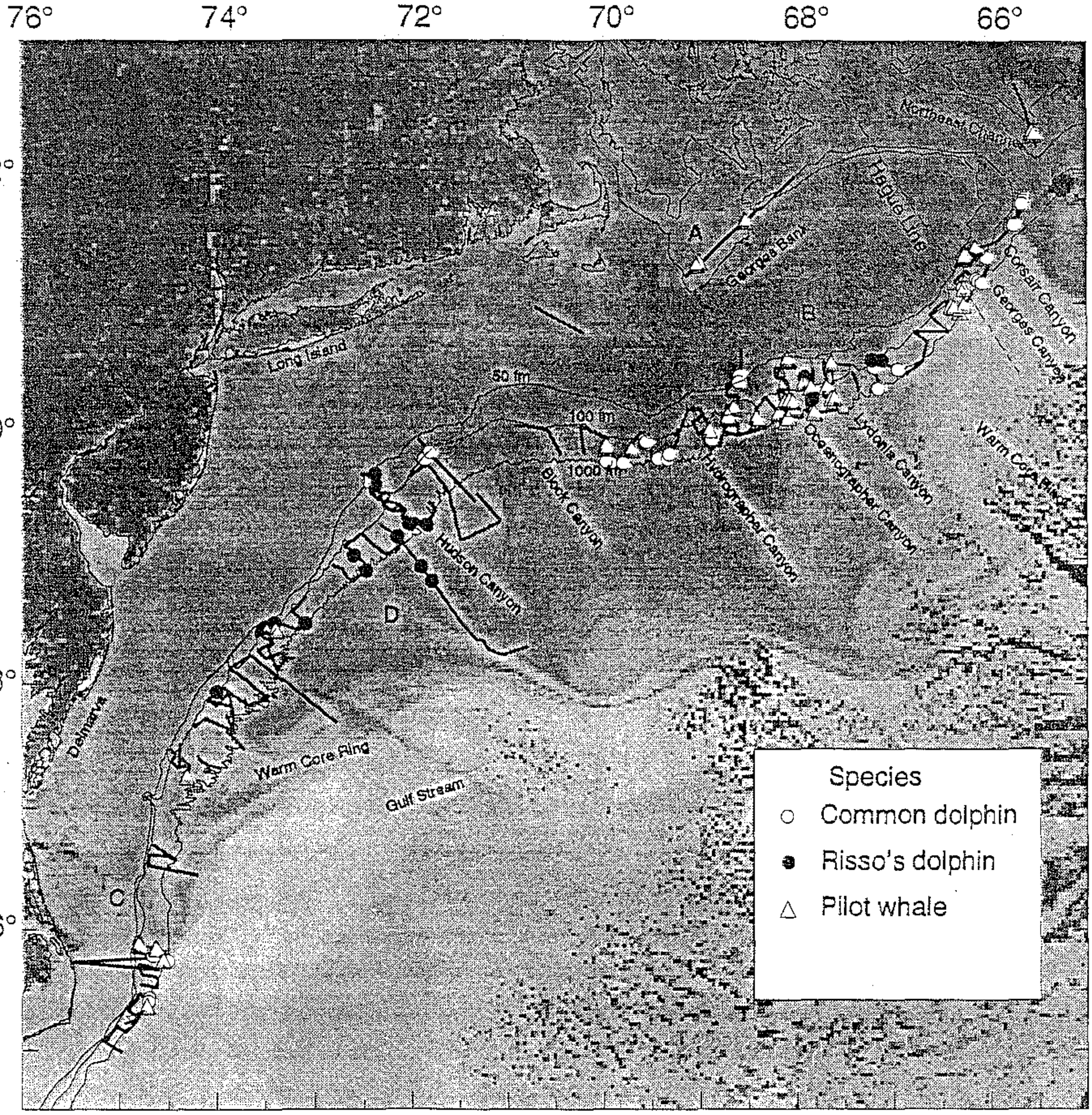

Figure 3. Distribution of common dolphin, Risso's dolphin, and pilot whale sightings made during R/V Chapman marine mammal survey, 8 June - 16 July 1991.

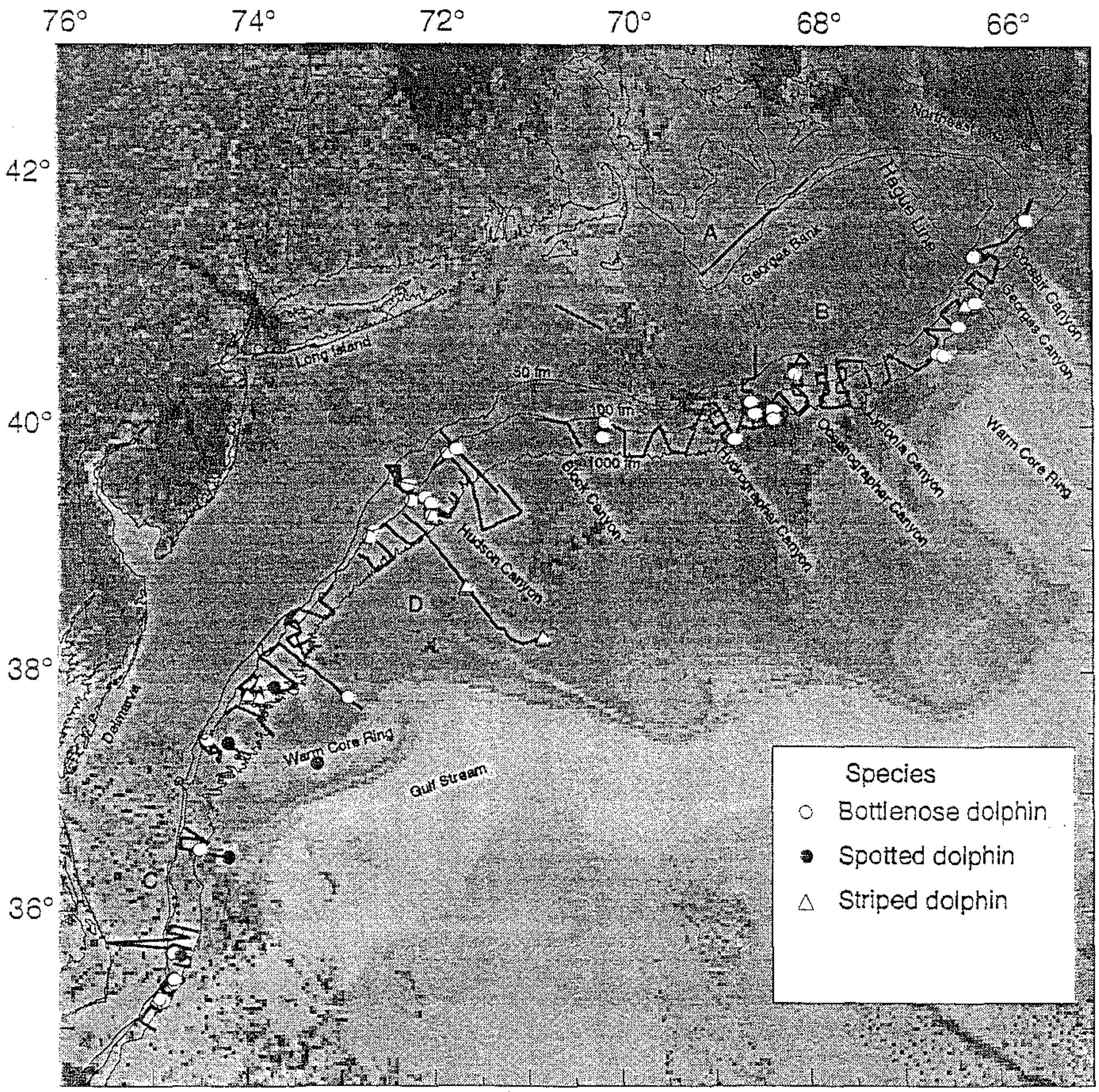

Figure 4. Distribution of bottlenose dolphin, spotted dolphin and striped dolphin sightings made during R/V Chapman marine mammal survey, 8 June - 16 July 1991.

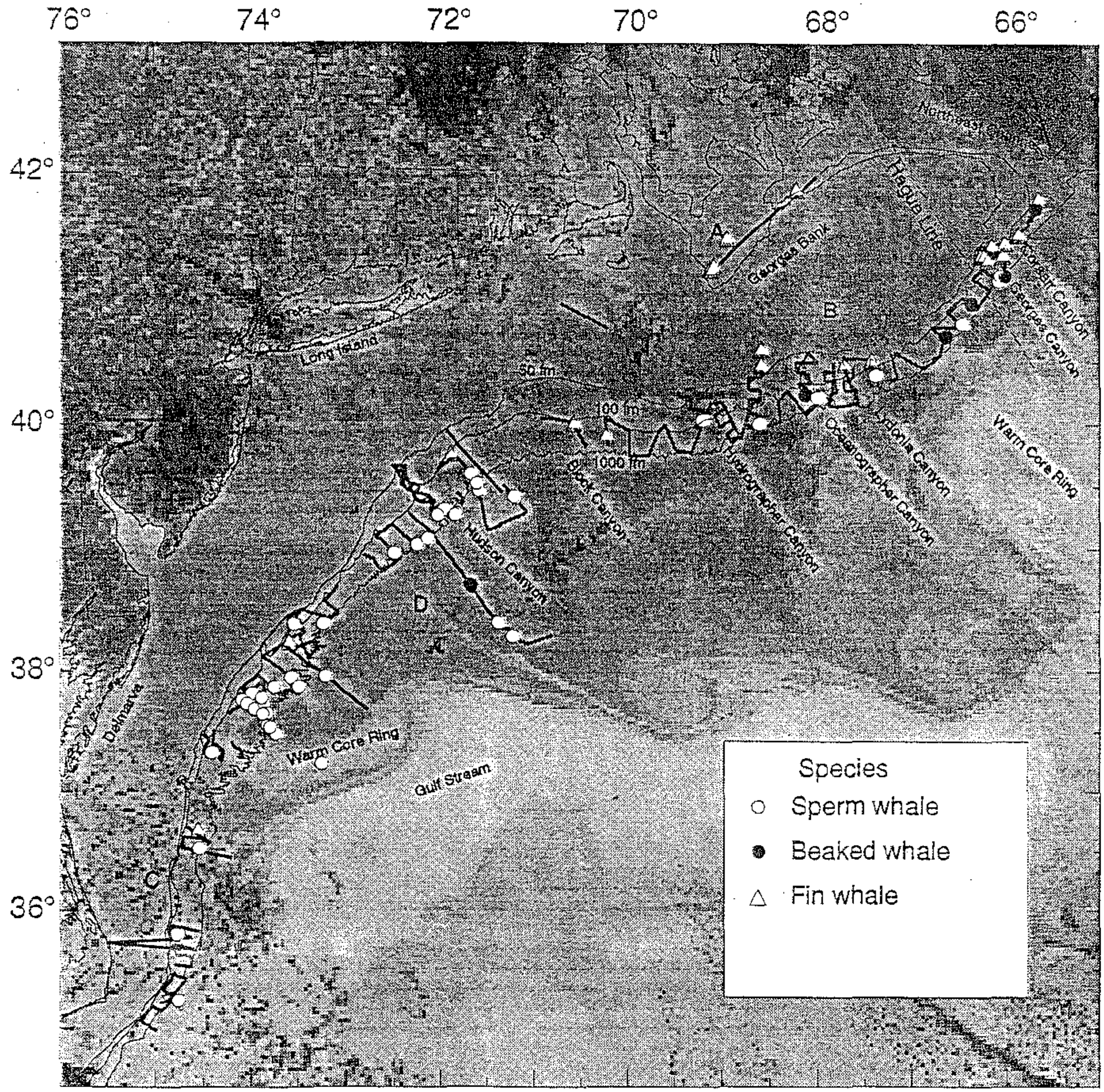

Figure 5. Distribution of sperm whale, beaked whale, and fin whale sightings made during R/V Chapman marine mammal survey, 8 June - 16 July 1991.